VERTICAL DISTRIBUTION OF MITES AND COLLEMBOLA IN RELATION TO SOIL STRUCTURE

NIELS HAARLØV

Zoologisk Laboratorium Den Kgl. Veterinær -og Landbohøjskole, København

Direct observations of soil sections from a small plantation north of Copenhagen made it possible to describe appropriately: (1) the cavity percentage of the soil structure; (2) the total length of the boundaries of the cavities measured on the section surface, and (3) the diameter of the largest circle lying free in the cavity of the sections. Only cavities with diameters of over 0·1 mm were considered. In connexion therewith, the vertical distribution of species and, further, that of the individuals were examined. There was found to be agreement between the vertical distribution of the Collembola and mites and the development of cavities; at the same time, however, their distribution should also be correlated with a number of other factors, for example, relative humidity and food. The average density of animals per unit area on the walls of the cavities seems to be very small.

In the present paper it is not intended to give a general survey of the vertical distribution of mites and Collembola in the soil, but only to try and show how the technique of HAARLØV and WEIS-FOGH (1953) can be used for a general description of the soil, serving thereby to give information on the shape and size of the niches and crevices inhabited by mites and Collembola. A more thorough treatment of the subject will be published later.

The habitat selected for describing the method is the soil of a plantation situated in Jægersborg Dyrehave just north of Copenhagen. The plantation was planted in 1919 on a permanent grass pasture, and consists of *Crataegus oxyacantha* mixed with a few *Alnus incana* and *Picea abies*. The trees stand so close together that no herbaceous vegetation could develop.

The soil belongs to the common, brown forest soil type with a litter layer developed all the year round. Under this is a fermentation layer about 1 cm deep, followed by a humus layer of similar thickness with a gradual transition to the underlying brown mineral soil containing humus.

In November and December, 1952 11 vertically orientated samples were taken at random, each with a surface area of 43 mm^2.

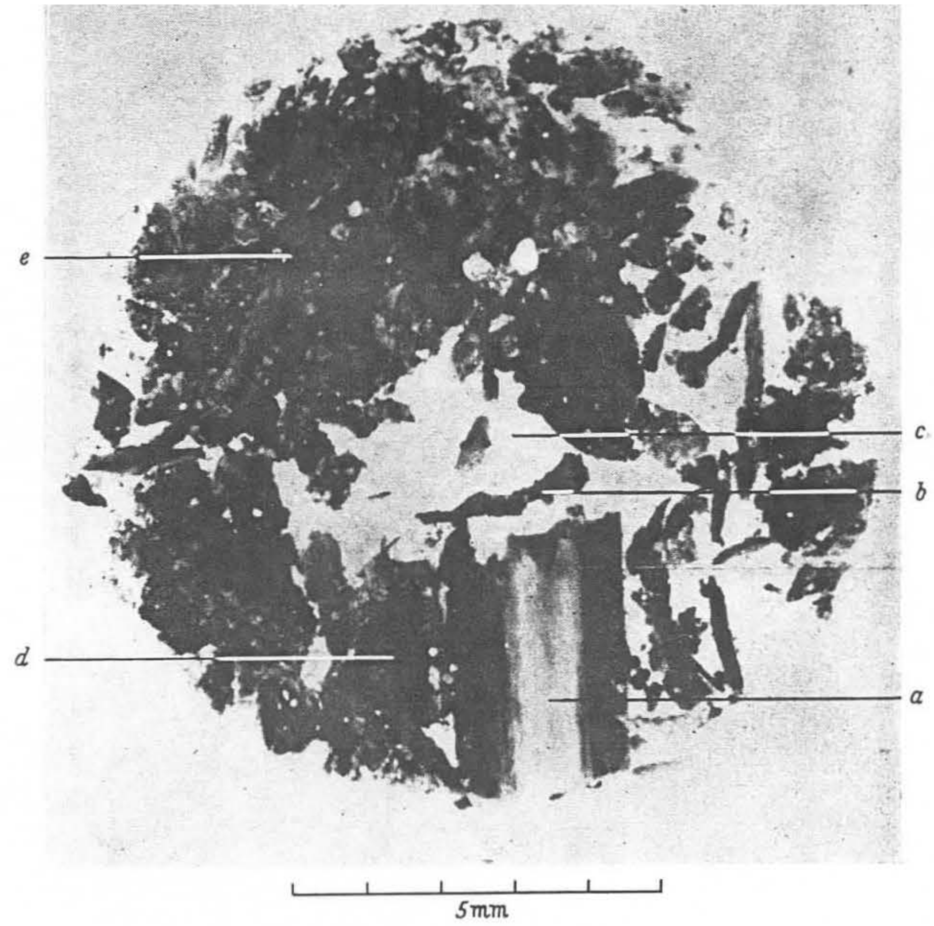

Figure 28—Soil from a plantation of Crataegus oxyacantha. *Horizontal section 0·75 mm thick from 10 mm below the surface. (a) A twig with white, fresh-looking wood, cut longitudinally; (b) piece of bark at margin of one of the larger cavities (c); (d) decaying leaf; (e) mineral soil containing humus. (From the original of Haarløv and Weis-Fogh (1953), by courtesy of Oikos.)*

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By means of the above mentioned technique (see also page 429) horizontal sections of the samples were cut in series, each section being 0·75 mm thick. In all there were 265 usable sections from the plantation. Unless expressly stated otherwise, all descriptions and measurements of the samples mentioned in the following text refer to the surface of the sections and to an enlargement of 12 diameters.

In *Figure 28* is reproduced a photograph of a soil section from the plantation, taken with a combination of transmitted and direct light. As a basis for the description of the sections the following three categories of inclusions have been distinguished at their section surfaces: (1) plant remains with visible structure; (2)

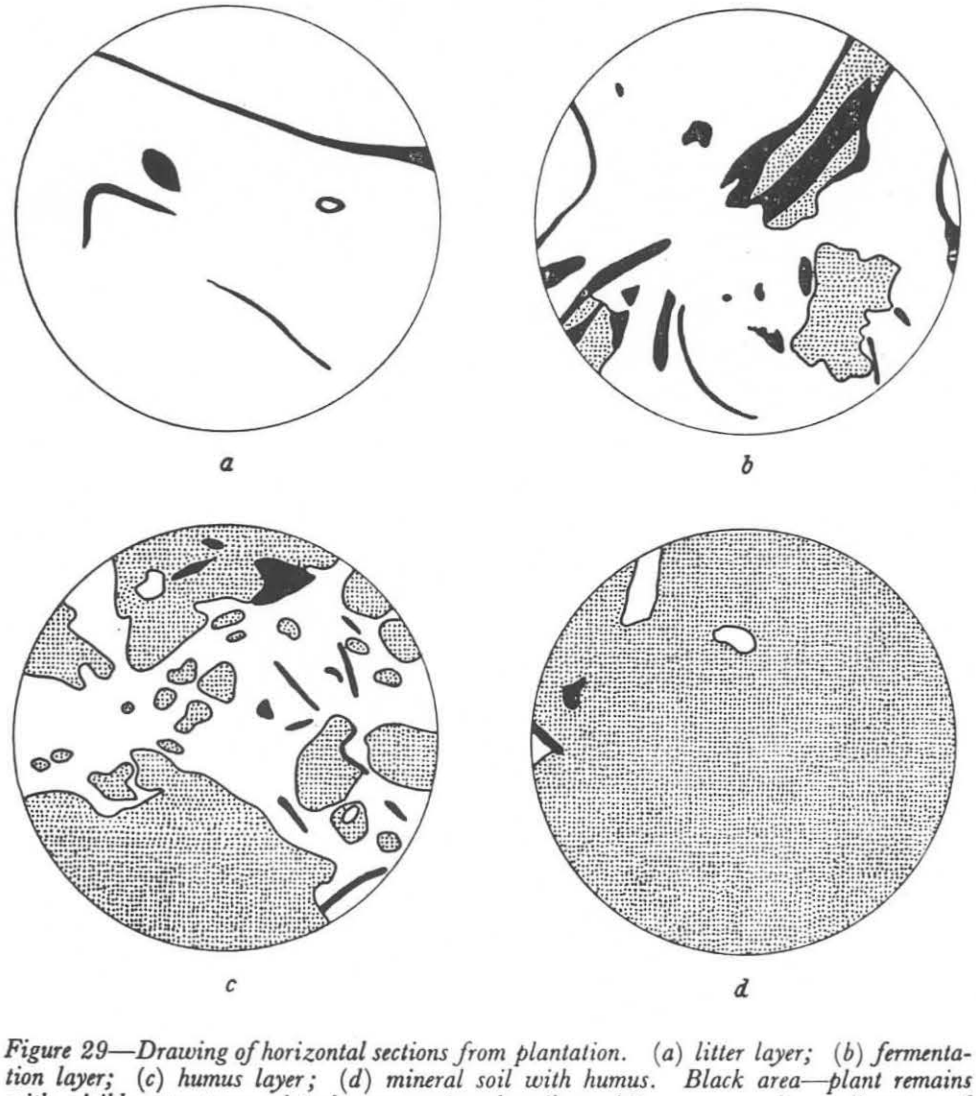

Figure 29—Drawing of horizontal sections from plantation. (a) litter layer; (b) fermentation layer; (c) humus layer; (d) mineral soil with humus. Black area—plant remains with visible structure; dotted area—mineral soil; white area—cavity; diameter of sections—7·4 mm.

mineral soil containing humus, plant remains (if any) without visible structure at the magnification used—this category is essentially composed of excrement; (3) cavities either going right through the section or only marked as depressions on the section surfaces—only cavities with a diameter greater than 0·1 mm have been considered.

Figure 29 (a–d) shows four typical sections at a vertical distance from each other of about 1 cm. In each illustration the outlines of the three above-mentioned categories of inclusions are drawn.

Figure 29 (*a*) comes from the litter layer the leaves of which still have the structure well preserved and are loosely deposited with few but large spaces between them. Sometimes excrement is to be found deposited on the leaves in the lowermost part of the litter layer. *Figure 29* (*b*) comes from the fermentation layer. The area of the cavities, as seen from the section surface, is considerably reduced when compared with the conditions in the litter layer, being partly due to the fact that the soil is more compressed here than in the over-lying layers and partly because the cavities, in an increasing degree, are filled with mineral components, mainly deriving from excrement. By the action of fungi, bacteria *etc* a great part of the structure of the plant remains has disappeared. *Figure 29* (*c*) comes from the humus layer, where the amount of the mineral soil containing humus has further increased at the expense of the cavities, and where the amount of plant remains with visible structure has decreased. In *Figure 29* (*d*) we are down in the brown mineral soil with few cavities and only small quantities of living and dead plant remains retaining visible structure.

Figures 30–32 show the results of different measurements on the section surfaces, the three figures being made in the same way. The ordinates indicate the depth; the circles give average values; on both sides the horizontal lines mark twice the standard error. For *Figure 30* the figures were calculated by weighing pieces of paper which in shape corresponded to the cavities, as these appear on the section surfaces. In *Figures 31* and *32*, however, direct measurements were made.

Figure 30 indicates the cavity percentage of the total area on the surface of the section. The illustration shows that the cavity percentage through the litter layer (1 cm) gradually declines from 100 per cent at the surface to somewhat lower values, but without showing greater fluctuations from one section to another. Through the following two centimetres the picture changes, however, showing a greater decline in the average values, the standard error at the same time indicating a great variation of the figures from one

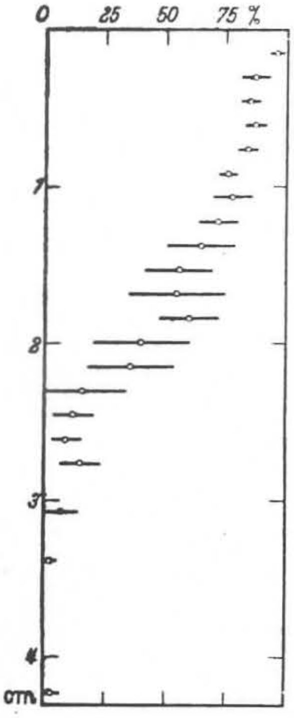

Figure 30—Cavity percentages measured on the surface of the sections (abscissae). Ordinate gives depths of samples.

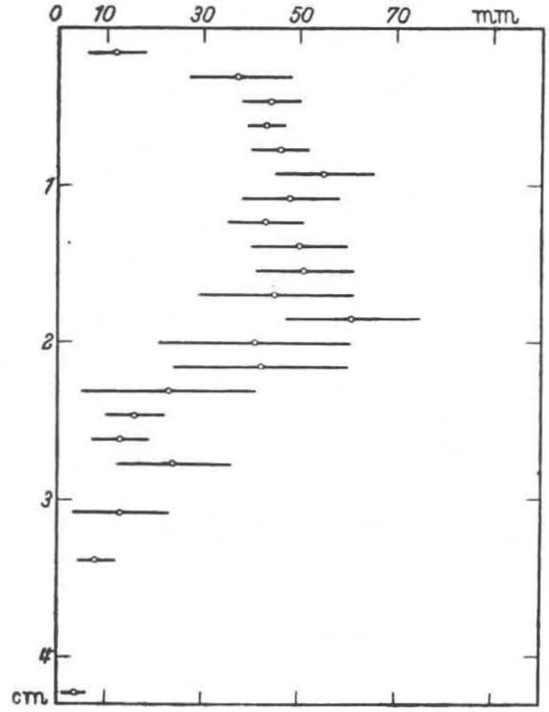

Figure 31—Measurements of the boundaries of the cavities, as they appear on the surfaces of the sections (abscissae). Ordinate gives depths of sections.

section to another. From a depth of 3 cm downwards the numerical data are certainly scanty, but still sufficient to show that conditions in the soil have now again become stable due to the great quantity of mineral soil and the small cavities. As regards development of cavities the fermentation and humus layers together appear as an intermediate zone between the distance up to the litter layer and down to the mineral soil.

In *Figure 29* (*a–d*) are indicated the boundaries of the cavities as they appear on the section surfaces. By adding for each section the lengths of these we get a figure which is directly proportional to the area of the walls of the cavities in the particular section.* Since, however, the thickness of the sections (0·75 mm) is great in proportion to the size of the cavities the shape of the cavities in the rest of the section need not correspond to what is seen on the section surface. Thereby these area-figures are subject to errors which may act in a positive as well as in a negative direction, and which it has not been possible to take into consideration.

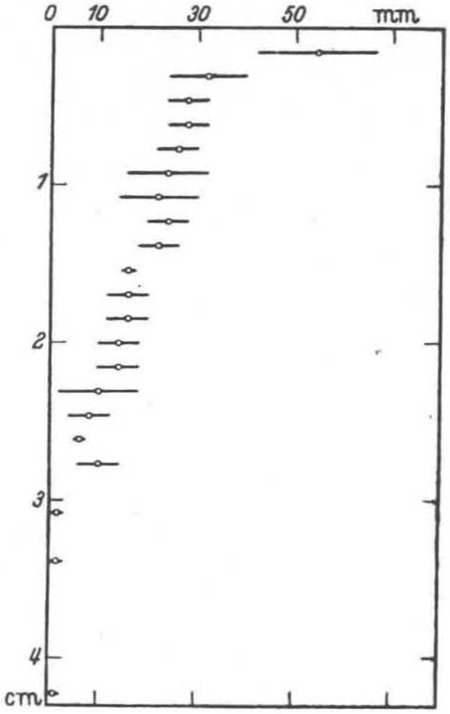

Figure 32—Lengths of the diameter in the largest circle which can lie free in the cavity system (abscissae). Ordinate gives depths of sections.

In the uppermost layer of the litter layer, where only a few solid elements are found, the measurements in *Figure 31* represent a few

* Illustrated by *Figure 31*, the circles indicating average values and the horizontal lines twice the standard error.

mm only, but already some distance downwards in the litter layer the figures rise to about 40 mm, that is considerably above the circumference of the section itself, at which level the measurements remain down to a depth of about 2 cm. Further down the measurements decrease strongly, showing great fluctuations from one section to another, and, finally, in the mineral soil, they fall to minimum values with only slight variation from one section to another. If *Figure 30* is compared with *Figure 31*, the latter shows, among other things, that a decrease in the cavity percentage need not necessarily be accompanied by a reduction of the internal surface area. It is evident from the sections drawn in *Figure 29* (*b* and *c*), that this is due to a division of the originally large cavities into a great number of smaller sections. Not until the cavity percentage falls below a certain value, which happens at about 2 cm, will the surface measurements follow suit.

For a further characterization of the cavity systems *Figure 32* has been worked out. It shows the length of the diameter in the largest circle which can lie free in the cavity system, seen from the section surface.

For a diameter size which is equal to the surface of the section of the litter layer, the size of the diameter declines strongly at the beginning, later through the remaining part of the litter layer and through the underlying layers more slowly and with small fluctuations from one section to another. Owing to the comparatively great thickness of the sections it cannot be seen from the figures whether the measurements were taken in closed cavities or in continuous tube systems. Consequently, one should be careful not to attach too great importance to the figures, but only take them as a general orientation in respect of the depth to which an animal of a certain width can be expected to penetrate.

The next problem will be to examine whether any correlation exists between the distribution of the animals in the soil and its structure.

In soil sections, mites (*Figure 33*) or Collembola (*Figure 34*) have often been observed. To try, on this basis alone, to form an idea of the distribution of the animals would, however, be a time-consuming task which would, in addition, require sections in which the thickness should be equal to the approximate breadth of the smallest of the animals which could be expected to occur in the soil; such thin sections could only be obtained in purely organic soils.

However, to get an idea of the distribution of the fauna samples, 44 in all were specially taken in 1952–54 for this purpose. Each sample was cylindrical, 1 cm high and 20 cm^2 in area at the ends.

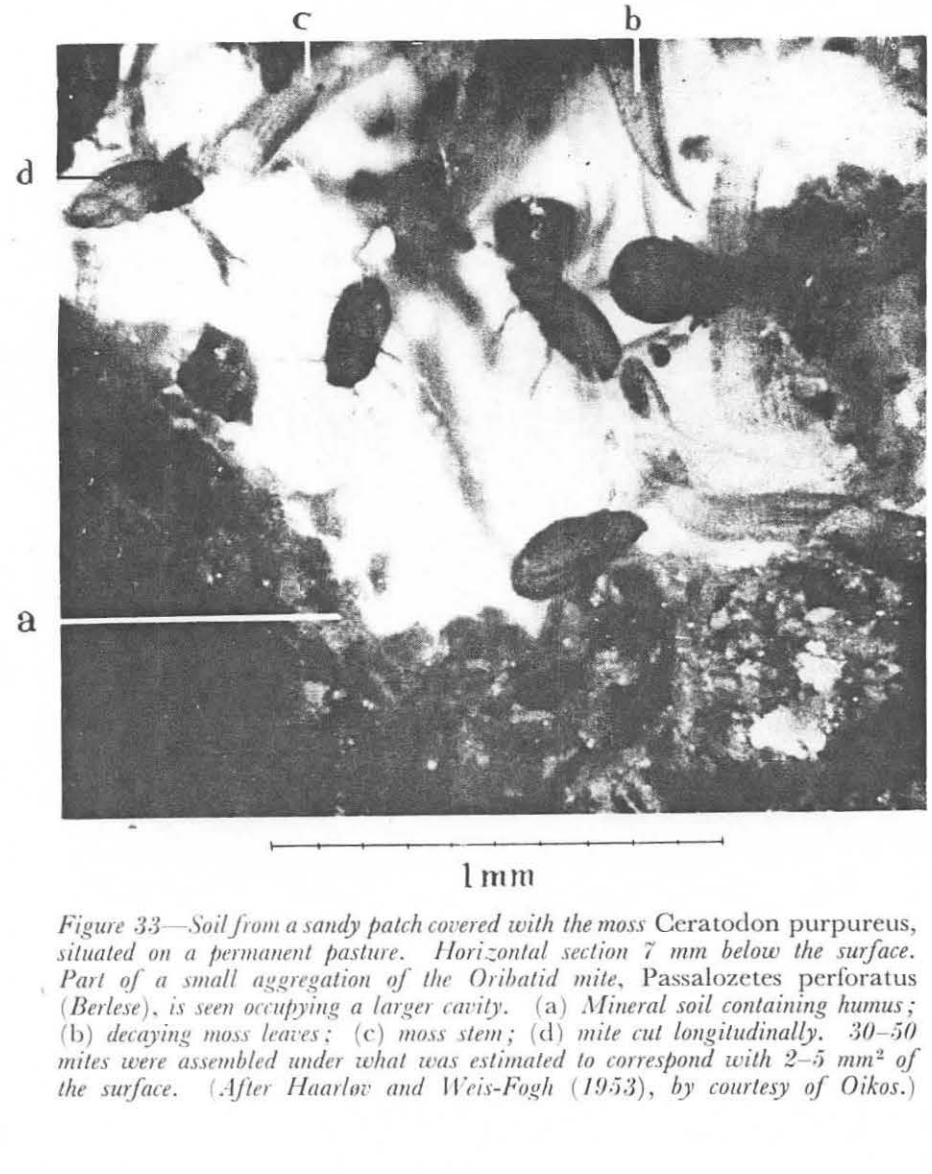

Figure 33—Soil from a sandy patch covered with the moss Ceratodon purpureus, *situated on a permanent pasture. Horizontal section 7 mm below the surface. Part of a small aggregation of the Oribatid mite,* Passalozetes perforatus *(Berlese), is seen occupying a larger cavity.* (a) *Mineral soil containing humus;* (b) *decaying moss leaves;* (c) *moss stem;* (d) *mite cut longitudinally. 30–50 mites were assembled under what was estimated to correspond with 2–5 mm² of the surface. (After Haarløv and Weis-Fogh (1953), by courtesy of Oikos.)*

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Figure 34—Typical section from the turf of a permanent grass pasture, 15 mm below the surface and above the mineral soil. (a) *Remains of leaves, stems and roots;* (b_1 *and* b_2) *the ubiquitous Collembolan,* Folsomia quadrioculata (*Tullb.*)*;* (c) *nymph of the common Oribatid mite* Tectocepheus velatus (*Mich.*). (*After Haarløv and Weis-Fogh* (*1953*)*, by courtesy of Oikos.*)

The depth of sampling is given in the accompanying tables. Most of the samples were taken in the uppermost 5 cm where the majority of the animals was expected to occur and the animals were expelled from the samples by means of the modified Tullgren apparatus described on page 333.

In Table 16 the total number of species from 1952–54 has been arranged according to the maximum breadth of the animals measured on fully grown individuals and according to their vertical occurrence.

Table 16 shows that the main part of the species, the large as well as the small, live at a depth of 3–4 cm and upwards into the uppermost layer of the litter layer. Below 3–4 cm only the small species are met with.

TABLE 16

Vertical distribution and maximum breadth of all arthropods sampled (1952–54)

cm \ mm	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9	>0·9
0–1	11	7	4	8	2	3	1	0	0	1
1–2	15	8	5	5	2	4	2	0	0	0
2–3	14	7	2	3	2	0	1	1	0	0
3–4	8	5	2	1	1	0	1	0	0	0
4–5	4	4	0	0	1	0	0	0	0	0
8–9	6	2	0	0	0	0	0	0	0	0
10–11	6	2	0	0	0	0	0	0	0	0
14–15	4	2	0	0	0	0	0	0	0	0
20–21	2	0	0	0	0	0	0	0	0	0
25–26	0	0	0	0	0	0	0	0	0	0
30–31	0	0	0	0	0	0	0	0	0	0
40–41	3	0	0	0	0	0	0	0	0	0
50–51	2	0	0	0	0	0	0	0	0	0

From the same samples Table 17, columns *a* and *b*, show the vertical distribution of individuals of a number of selected species (HAARLØV, 1952)—partly in absolute figures, *a*, partly in percentages, *b*—and further the total number of individuals per sample is indicated in the bottom line.

Since the numerical data for the samples from 1952–54 are not sufficient for calculating the standard deviation, and since presumably a fairly large number of individuals was lost during the sampling and the ensuing treatment in the Tullgren apparatus, a greater value is ascribed to the percentage figures than to the absolute figures. Too much importance should, however, not be attached to the percentages; they should merely be taken to indicate the vertical distribution of the species. Such percentages might, however, be employed if other more satisfactory material were available from the

same habitat, even although this only yielded the total number of individuals per sample and not their vertical distribution.

Just such material is available: it consists of 25 samples (cylinders: 10 cm² × 6–7 cm) taken separately in the same plantation at regular intervals from April 1942 to March 1943.

Applying the percentages from 1952–54 to this material the results listed in Table 17 column *c* under 1942–43 appeared. In the bottom

TABLE 17

Vertical distribution and maximum breadth of selected arthropod species, sampled 1952–54 and 1942–43

Species	Brachychthonius *spp.*			Friesea mirabilis			Isotomiella minor			Suctobelba *spp.*			Tullbergia krausbaueri			Chamobates schützi		
Breadth	0·1 *mm*			0·1 *mm*			0·1 *mm*			0·1 *mm*			0·1 *mm*			0·2 *mm*		
Date	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43
Depth cm	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
0–1	6	15%	5	1	13%	1	11	44%	3	2	13%	3	1	3%	2	2	50%	9
1–2	20	50%	17	1	13%	1	10	40%	3	10	67%	14	4	14%	8	1	25%	4
2–3	4	10%	4	1	13%	1	2	8%	1	3	20%	4	4	14%	8	1	25%	4
3–4	2	5%	2	0		0	1	4%	0	0		0	2	7%	4	0		0
4–5	1	3%	1	0		0	0		0	0		0	2	7%	4	0		0
8–9	1	3%	1	1	13%	1	1	4%	0	0		0	10	34%	19	0		0
10–11	3	8%	3	1	13%	1	0		0	0		0	4	14%	8	0		0
14–15	0		0	1	13%	1	0		0	0		0	2	7%	4	0		0
20–21	1	3%	1	0		0	0		0	0		0	0		0	0		0
25–26	0		0	0		0	0		0	0		0	0		0	0		0
30–31	0		0	0		0	0		0	0		0	0		0	0		0
40–41	1	3%	1	1	13%	1	0		0	0		0	0		0	0		0
50–51	0		0	1	13%	1	0		0	0		0	0		0	0		0
Total	39		35	8		8	25		7	15		21	29		57	4		17
Range			8–117			0–16			0–36			1–53			7–170			6–32

Species	Eupodes viridis			Folsomia quadrioculata			Isotoma notabilis			Veigaia serrata			Notaspis coleoptratus			Platynothrus peltifer			*Total number of individuals*		
Breadth	0·2 *mm*			0·2 *mm*			0·2 *mm*			0·2 *mm*			0·5 *mm*			0·6 *mm*					
Date	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43	1952–54		1942–43
Depth cm	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
0–1	14	34%	4	0		0	8	33%	7	1	8%	1	2	11%	4	1	50%	15	91	23%	78
1–2	20	50%	6	1	100%	11	14	59%	12	2	17%	1	10	15%	22	1	50%	15	170	42%	142
2–3	4	10%	2	0		0	1	4%	1	1	8%	1	4	22%	8	0		0	51	13%	44
3–4	1	3%	0	0		0	1	4%	1	1	8%	1	1	6%	2	0		0	22	6%	20
4–5	1	3%	0	0		0	0		0	1	8%	1	1	6%	2	0		0	9	2%	7
8–9	0		0	0		0	0		0	3	26%	3	0		0	0		0	21	5%	17
10–11	0		0	0		0	0		0	2	17%	1	0		0	0		0	15	4%	14
14–15	0		0	0		0	0		0	1	8%	1	0		0	0		0	6	2%	7
20–21	0		0	0		0	0		0	0	0	0	0		0	0		0	2	1%	3
25–26	0		0	0		0	0		0	0	0	0	0		0	0		0	0		0
30–31	0		0	0		0	0		0	0	0	0	0		0	0		0	0		0
40–41	0		0	0		0	0		0	0	0	0	0		0	0		0	3	1%	3
50–51	0		0	0		0	0		0	0	0	0	0		0	0		0	2	1%	3
Total	40		12	1		11	24		21	12		10	18		38	2		30	392		338
Range			1–23			0–47			0–59			0–30			15–156			2–73			159–611

line of the table is given the average number of individuals for the 25 samples and their range, and in the last column the total number of individuals per sample with its range. On the basis of these figures and the percentages *b* from 1952–54 the respective vertical distribution has been calculated, *c*. For correction of some of the figures it should be pointed out that the samples were not taken deeper down than 6–7 cm, which assumes that species occurring below this depth are comparatively scarce in the overlying layers. This does not however give errors of any importance.

If we first consider the vertical distribution of the total number

of individuals it again appears that the majority of the animals occurs at 3–4 cm and above, and within this distance especially at 1–2 cm from the surface, that is in the fermentation layer.

If we look at the vertical distribution of single species we find especially that it is such small forms as *Brachychthonius* spp., *Friesea mirabilis* (Tullb.) and *Tullbergia krausbaueri* Börn. which penetrate into the deeper layers. It is worth noticing that other species of the same size do not go so far downwards but remain in the uppermost 3–4 cm. This is true for both *Suctobelba* spp. and *Isotomiella minor* (Schaeff.). Among larger species it seems, as a rule, that only *Veigaia serrata* Willm. (G. O. Evans det.) occurs in the mineral soil.

Besides giving an estimation of the distribution of single species the study of the vertical distribution of these gives also a useful correction for the figures for the total distribution of the mites and Collembola in the soil (Table 17), since they show that a number of individuals may, for instance, be met with below 4–5 cm; but that

these are recruited from few species which chiefly belong to groups comprised of small forms.

Judging from the structure of the soil, as illustrated by the curves, the mites and Collembola might live in the litter layer as well as in the fermentation layer, while the size and shape of the niches in the mineral layer will no longer suit them.

That the fermentation layer, however, and not the litter layer contains the highest number of species and individuals is due to many factors. The shape and size of the cavities might be one of them. During dry seasons the litter, with its big cavities where the creatures are exposed to the drying-out effect of the atmosphere, will expel the animals. Furthermore, the leaves which are fundamental to the existence of the Collembola and mites are normally not sufficiently exposed to the action of fungi, bacteria *etc* in the litter to be fit for food for the animals.

The vertical distribution of the Collembola and mites in the soil thus seems to depend on a complex of factors of which the most important, presumably, are the size and shape of the cavities, their relative humidity and presence or absence of food.

As it is seen that most of the Collembola and mites—species as well as individuals—are found in the fermentation layer further ecological investigations on these two groups in the plantation can be restricted to a study on this layer.

What has been said above of the structure of the soil and the vertical distribution of the animals in relation thereto is directly concluded from the observations made. In what follows an attempt will be made to draw some further conclusions, the reliability of which, however, it is not yet possible to check.

What it is desired to discover in the first place is the area of the walls of the cavities, which represent the surface on which the animals are able to move, illustrated by Table 18 (*a–d*).

Such a calculation must be made on the basis of the measurements given in *Figure 31*, which—as will be remembered—were proportional to the inner surface and which referred to a column with a surface area of 43 mm². If such a column is divided into pieces of 5 mm each (Table 18 (*a*)) we get for each division a number of sections where the average figures for the measurements in *Figure 31* can be calculated (Table 18 (*b*)). If this figure is multiplied by the height of the column (Table 18) we get a measurement for the area of the walls of the cavities in a 5 mm high column with a surface area in the present case of 43 mm² for cavities with diameters above 0·1 mm. In addition (Table 18 (*d*)) the measurements from (*c*) are multiplied by 23 in order to correspond with a sample with a

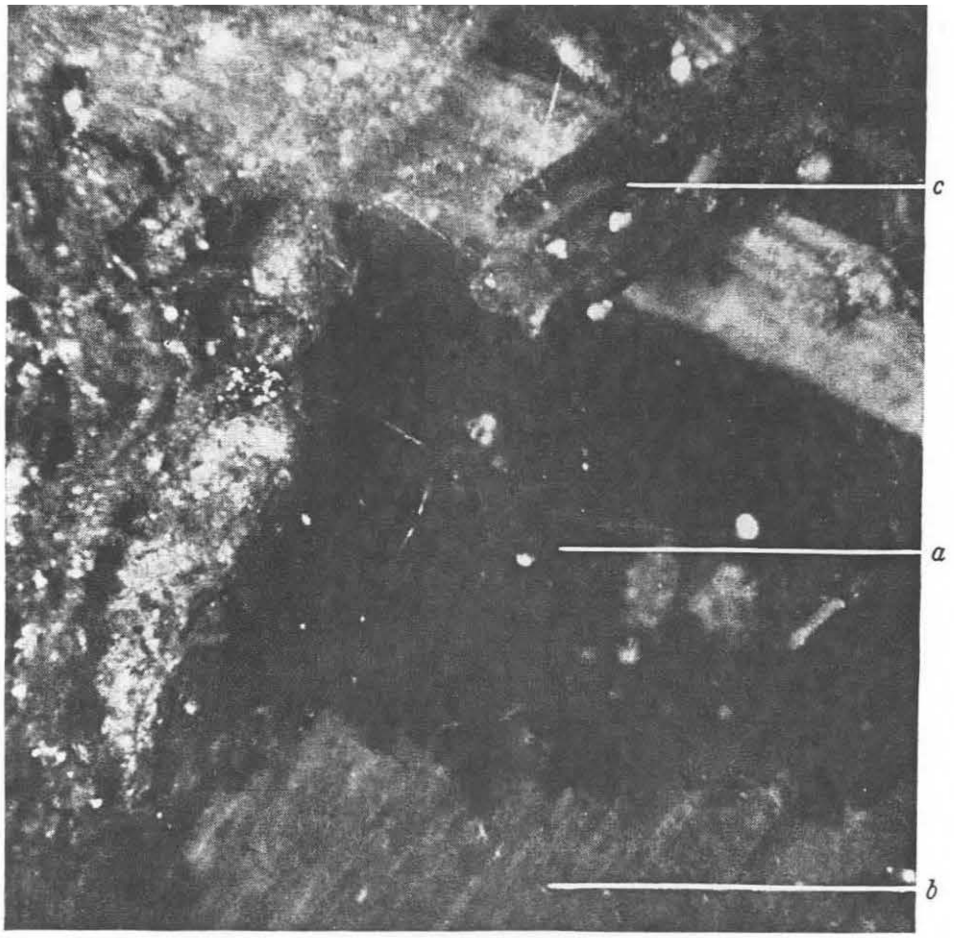

Figure 35—Same locality as Figure 28. Section through the lower part of the fermentation layer, 15 mm below the surface. Thin, white fungal hyphae are stretched across the main cavity (a) and between a piece of decayed wood (b) and a twig (c). (From the original of Haarløv and Weis-Fogh (1953), by courtesy of Oikos.)

TABLE 18

Surface area available upon which animals can move—for explanation see text

a *mm*	*b* *mm±S.D.*	*c* mm^2	*d* mm^2
0–5	31±19	155	3900
5–10	48±15	240	5500
10–15	47±18	235	5400
15–20	50±28	250	5800
25–30	15±14	75	1700
30–35	8±6	40	900
35–40	5±5	25	600

surface area of 1000 mm^2, which is the sample size to which the series from 1942–43 refers.

Since the measurements in *Figure 31* (as stated on page 171) are not quite reliable—how unreliable they are cannot be ascertained—the figures in Table 18 should be treated with great caution and should presumably be regarded as minimal figures.

Another point of inaccuracy which must be taken into consideration is that just as the real inner surface—besides the walls of the cavities themselves—should be reckoned with so also should the network of fungal hyphae which extends from one wall to another (*Figure 35*) be taken into account.

Bearing these reservations in mind it is desired to point out that if we compare the average figures for the total number of Collembola and mites found in the respective layers with the areas which seem to be at their disposal it is seen that from a depth of 0–4 cm about 1 animal is found per 100 mm^2. If we consider only the sizes and number per sample of the 12 species listed in Table 17 we come to the conclusion that all the individuals of these species from a depth of 0–4 cm cover only about one part per thousand or less of the total area.

I wish to extend my sincere thanks to Professor Math. Thomsen, Mr. Broder Beier Petersen, and Dr. Torkel Weis-Fogh, for their criticism and advice.

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DISCUSSION

MR. C. A. T. EDWARDS: I should like to ask Mr. Haarløv if he carried out sampling by means of Tullgren extraction at the same time as he made samples for sectioning. Also, does the dampness of the sample affect the number of animals found ?

MR. HAARLØV: Samples were not made at the same time but at comparable times in different years. I do not, however, think that this makes for any serious errors. Less dampness in the litter layer (as for example in a dry summer) results in fewer animals.

DR. P. W. MURPHY: Are there differences in vertical distribution between Acarina and Collembola ?

MR. HAARLØV: No differences are apparent between the groups, but differences exist between certain species within the groups.

MR. J. HOBART (Department of Agricultural Zoology, University College, Bangor): From a study of the soil sections did Mr. Haarløv find the majority of the meiofauna in the very large cavities or were some of them wedged in the smaller tunnels suggesting perhaps that they pushed their way between the soil particles ?

MR. HAARLØV: I found it difficult to decide this point.

MR. A. MACFADYEN: How do Mr. Haarløv's experiences of the seasonal variation of vertical distribution of micro-arthropods agree with those of other workers in the published literature ? Dr. Strenzke, for instance, reported for North Germany an annual migration involving movements to deeper layers in the winter. This appears not to be the case in different soils and perhaps a milder climate in English conditions as reported by myself and Ford accounts for this.

MR. HAARLØV: I prefer to follow the English workers. I have not noticed a decrease in numbers in relation to phenological conditions. However, I might mention a seasonal fluctuation in the Collembola: no eggs hatch in winter so proportionally more adults are apparent at this time. Also with certain mites, larvae were found only in August and September.

PROFESSOR W. TISCHLER: The different results on vertical migration of mites between the investigations made by Strenzke and by Mr. Haarløv may be due to the fact that the former took samples predominantly in open biotopes, the latter in woodland.

MR. HAARLØV: I have studied the meiofauna in both grassland and woodland and did not find a vertical migration. Animals are concentrated in the layers where biological activity is greatest.

DR. G. O. EVANS: Strenzke's investigations deal with the Oribatid mites only. The immature stages of this group appear to reach their

maximum numbers in autumn and winter. It is possible that these stages, because of their smaller size *etc*, might penetrate into the deeper layers of the humus and even into the sub soil during this time of the year.

MR. HAARLØV: It is possible, but I see no reason why this migration should occur.

MR. J. G. SHEALS: As long ago as 1939 evidence of vertical migration in *Onychiurus* sp. was recorded. I have also found some evidence of migration in Oribatid adults but this evidence is a little inconclusive.

MR. HAARLØV: This may be so if, for instance, the humus layers are relatively thick, but in my observations it was not found.

MR. D. H. MURPHY: In a site I have examined, certain species of Collembola that normally occur in the deep layers are able to migrate up and down during the year, but those species living in the upper humus layers of the soil cannot penetrate into the underlying mineral soil. The species probably can migrate within their vertical range, but if this vertical range is limited migration may not be apparent.

MR. M. E. DUFFEY (Nature Conservancy, Norwich): By examination of the sections is it possible to say to what extent the soil cavities are created by physical processes and to what extent the soil animals make a contribution to cavity formation ?

MR. HAARLØV: A pedologist might be able to make this differentiation, but it is my impression that in the fermentation and humus layers, the structure of the soil is very much influenced by the soil animals.

MR. B. O'CONNOR (Department of Zoology, University College, Bangor): Has Mr. Haarløv any means of distinguishing between air-filled and water-filled pore spaces ?

MR. HAARLØV: No, because the agar used in sectioning the soil is water-soluble. Normally, I think, the cavities in the soil under discussion are air-filled.

MR. J. G. BLOWER: Has Mr. Haarløv considered the possibility of modifying his method to provide data concerning the amount of air enclosed within soil spaces during flooding of the surface ? This is a factor of great significance in the survival of certain myriapods, for instance, which are susceptible to wetting. Could an indication of included air be obtained by freezing and sectioning the soil prior to impregnation ?

MR. HAARLØV: Since the embedding medium is water-soluble no indication of water and air in spaces from my method are possible. By freezing it will not be possible to estimate the water content of the cavities because the ice eventually forming in the pore spaces may derive either from water in the cavities or from water which was originally present on the walls of the cavities.

EDITOR'S NOTES It might be of interest, in view of some of the above remarks, to draw attention to a recent paper which contains relevant information on vertical distribution and seasonal variation in eastern north America, and discusses possible causes of population differences in Collembola and mites. The title is: Bellinger, P. F., 1954, Studies of soil fauna with special reference to the Collembola. *Connecticut agric. Exper. Sta. Bull.*, **583,** 67 pp.